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The development of downside accounting beta as a measure of risk[1]

Anna Rutkowska-Ziarko[2], Christopher Pyke[3]

Abstract: This paper develops a new method for measuring market risk called downside accounting beta (DAB). To test the validity of DAB the method is applied to the financial data for 14 food companies listed on the Warsaw Stock Exchange during a 6-year period. DAB calculates how changes in the profitability of the whole sector affects the profitability of a given company. The paper concludes that when calculating DAB using Return on Assets (ROA) and Return on Equity (ROE) there is a positive correlation with market betas. The practical implication of this research is that investors, owners and managers can use DAB to calculate the systematic risk of companies not listed on stock markets and consequently to identify the levels of risk associated with companies within the sector.

Keywords: downside accounting betas, downside risk, lower partial moments, semi--variance, capital asset pricing, food company sector.

JEL codes: G11, G12, G32, M40.

Introduction

This paper is an extension of research previously presented by Rutkowska--Ziarko (2015), which concluded that the total risk, defined as variability and semi-variability of the stock prices, is affected by the changeability of profit earned by the company. The aim of this paper is to propose a method for calculating downside accounting betas. In addition the paper analyses the relationship between market betas and accounting betas using the variance and semi-variance approach.

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Beta is a measure of the systematic risk of a financial security, Sharpe's CAPM model (1964) calculates market beta using the market price of stocks. However Sharpe's market beta can only be applied to firms listed on the capital market, as it is impossible to estimate the systematic risk for unlisted companies. There are some methods using the CAPM model which calculate the approximate level of systematic risk for non-listed companies. Using the Hamada model (1972) a non-listed company is compared to companies within the same sector listed on the capital market. It makes the assumption that all companies in the specified industry have similar level of systematic risk if they have a similar capital structure.

Accounting beta was first proposed by Hill and Stone (1980) and is similar to market beta. It is assumed that accounting returns are generated by a statistical process which is structurally similar to generating stock market returns (Hill & Stone, 1980). Accounting beta can be used as an additional tool for calculating the systematic risk of companies listed on the capital market. Accounting beta can also be calculated for non-listed companies to estimate their risk, instead of market beta (Sarmiento-Sabogal & Sadeghi, 2015). However there are two main limitations, the first is the availability of the accounting data and the second is the infrequent preparation of financial statements (i.e. annually). Market betas measure the sensitivity of the return from the shares of a given company which are caused by changes in the return of the market portfolio (or market indexes). Whereas accounting betas measure the sensitivity of the profitability ratio of a given company caused by changes in the profitability of the whole sector. The research undertaken by Sarmiento-Sabogal and Sadeghi (2015) found a link between accounting betas and market betas. In their research they use a data set taken from US-listed firms whose annual accounting information was available in COMPUSTAT.

A common approach to calculating accounting beta is by using variances as a risk measure [e.g. Hill & Stone, 1980; Campbell et al., 2009; Mensah, 1992; Nekrasov, 2009; Sarmiento-Sabogal & Sadeghi, 2015). However one of the drawbacks of using this measure of risk is that negative and positive variances from the expected rate of return are treated in the same manner. In fact negative variances are undesirable, while positive ones create an opportunity for a higher profit (Rutkowska-Ziarko, 2013; Pla-Santamaria & Bravo, 2013; Klebaner et al., 2017). Others, (Harlow & Rao, 1989; Estrada, 2002; Post & Viet, 2006; Galagedera & Brooks, 2007; Markowski, 2015) argue that downside market beta is a better measure of risk than the mean-variance model.

This paper is structured as follows. The first section deals with the concept of downside accounting beta. The second section examines the data set and provides the empirical results. Conclusions close the paper.

1. Market Beta, Accounting Beta and Downside Risk

Portfolio analysis and the theory of risk in the capital markets considers total risk and systematic risk. Total risk is related to the variability of the rate of return. This variability can be measured in different ways using classical measures of risk, for example variance, semi-variance or lower partial moments. Systematic risk is related to the influence of the rate of return of a market portfolio and to the rate of return of a given security. The classical measure of systematic risk is beta coefficients (β_i) used in Sharpe's CAPM model is usually calculated as follows:

$$\beta_i = \frac{COV_{iM}}{S_M^2}, \tag{1}$$

where:

COV_{iM} – covariance of the rate of return for stock i and market portfolio rates of return,

S_M^2 – variance of market portfolio rates of return.

In this approach it is assumed that investors display mean–variance behaviour (Estrada, 2002). If investors treat risk as the possibility of losing, or not earning enough, compared to a given target point then the appropriate measure of systematic risk should be downside beta (β_i^{LPM}), calculated as follows (see Price et al., 1982):

$$\beta_i^{LPM} = \frac{CLPM_i^2}{dS_M^2(f)}, \tag{2}$$

where:

$CLPM_i^2$ – asymmetric mixed lower partial moment of second degree for stock exchange listed company i,

$dS_M^2(f)$ – semi-variance of the market portfolio determined in relation to the risk-free rate of return.

In this paper it is assumed that when determining both semi-variance and the lower partial moment that the reference point is the risk-free rate (R_{ft}) when changing its value from one period to another.

The asymmetric mixed lower partial moment of second degree is calculated as follows (Price et al., 1982):

$$CLPM_i^2 = \frac{1}{T-1}\sum_{t=1}^{T}(R_{it} - R_{ft}) * lpm_{Mt}, \tag{3}$$

where:

$$lpm_{Mt} = \begin{cases} 0 & \text{for} \quad R_{Mt} \geq R_{ft} \\ R_{Mt} - R_{ft} & \text{for} \quad R_{Mt} < R_{ft} \end{cases},$$

R_{Mt} – market portfolio rate of return in the period t.

In a similar way the semi-variance of the market portfolio is calculated:

$$dS_M^2(f) = \frac{\sum_{t=1}^{T} lpm_{Mt}^2}{T-1}. \tag{4}$$

In determining the downside beta coefficients those periods in which the market rate of return is higher than the risk-free rate of return are disregarded. Both kinds of betas could be regarded as the "market beta" as the market rate of return is used to calculate the systematic risk.

To calculate accounting beta one of the profitability ratios can be used instead of market rate of return. The market rate of return is the relative change in stock price in any given period which may, or may not, include dividend. However a key question is how does the profitability of the whole market, or the sector, influence the profitability of company *i*?

The accounting beta coefficient for Return on Assets ($\beta_i(ROA)$) could be calculated as follows (Hill & Stone, 1980):

$$\beta_i(ROA) = \frac{COV_{iM}(ROA)}{S_M^2(ROA)}, \tag{5}$$

$COV_{iM}(ROA)$ – covariance of the profitability ratio of company *i* and market portfolio ratios (market indices of profitability ratios),
$S_M^2(ROA)$ – variance of market profitability ratios.

In this way we can calculate the accounting beta for different profitability ratios such as Return on Assets (ROA), Return on Equity (ROE), Return on Sales (ROS), as well for other accounting ratios. This approach is also related to accounting-based risk management and accounting rate of return (Toms, 2012, 2014). Accounting rate of return can be regarded as the relative change in the book value of the company.

An interesting study about the relationship between accounting information and systematic risk was undertaken by Amorim et al. (2012). They suggest in their panel data model that uses accounting variables, that accounting beta means the regression coefficients, where the dependent variable is market beta. They offer a different approach to the one used by Hill and Stone (1980), where the accounting beta is used to understand the sensitivity of the accounting profitability ratio of a given company caused by changes in the accounting profitability ratio of the whole sector.

The main problem with applying the concept of downside market beta to accounting beta is the target level of a given ratio. To calculate the market beta the risk-free rate is used, however there is not anything similar for accounting ratios, which is one of the limitations of the proposed methodology. One of the solutions is to use the average level of a financial ratio in each sector as the target point. The same approach has been proposed for calculating semi-variance of profitability ratios in work by Rutkowska-Ziarko (2015).

Let us try to define downside accounting beta for ROA:

$$\beta_i^{LPM}(ROA) = \frac{CLPM_i^2(ROA)}{dS_M^2(\overline{ROA}_M)}, \tag{6}$$

where:

$\overline{ROA}_M$ – average level of ROA for all analysed companies in the sector,

$\overline{ROA}_M = \frac{1}{T}\sum_{t=1}^{T} ROA_{Mt}$,

$ROA_{Mt} = \sum_{i=1}^{k} w_i * ROA_{it}$,

$w_i = \frac{MV_i}{\sum_{i=1}^{k} MV_i}$,

MV_i – market value of company i,

$dS_M^2(\overline{ROA}_M)$ – semi-variance of the market portfolio determined in relation to the average level of ROA.

$$CLPM_i^2(ROA) = \frac{1}{T-1}\sum_{t=1}^{T}(ROA_{it} - \overline{ROA}_M) * lpm_{Mt}(ROA) \tag{7}$$

where:

$$lpm_{Mt}(ROA) = \begin{cases} 0 & \text{for} \quad ROA_{Mt} \geq \overline{ROA}_M \\ ROA_{Mt} - \overline{ROA}_M & \text{for} \quad ROA_{Mt} < \overline{ROA}_M \end{cases}.$$

Similarly the semi-variance of the ROA for the whole sector is calculated:

$$dS_M^2(\overline{ROA}_M) = \frac{\sum_{t=1}^{T} lpm_{Mt}(ROA)}{T-1}. \tag{8}$$

The downside accounting beta (DAB) for a profitability ratio could also be defined in a similar way. DAB represents how changes in the profitability of the whole sector affect the profitability of a given company in a weak position. A weak position is defined as a period when the average profitability ratio for the company is lower than average level in the sector.

Research by Konchitchki et al. (2016) on accounting-based risk and downside risk using data from Compustat North America Fundamentals Annual

File identified the concept of earnings downside risk where ROA is used as the measure of earnings. The measure of downside risk earnings is calculated using the relationship between lower and upper partial moments for ROA.

2. Application of Downside Accounting Beta (DAB) to the Food Company Sector

To test the application of DAB the data for 14 food companies listed on the Warsaw Stock Exchange was collected and analysed during the period 1 January 2010 – 30 June 2016. In addition quarterly financial statements during the period between Quarter 4 2009 and Quarter 1 2016 were also analysed for the 14 food companies.

The quarterly financial reports used by investors always refer to a company's performance in the previous quarter. Therefore, in this study a quarter back shift is applied to the financial data so that it matches with the market share prices. A time series of quarterly rates of return and profitability ratios: ROA, ROE and ROS were determined for every company. The WIG index was taken as a market portfolio and the Warsaw Interbank Offer Rate (WIBOR 3M) for three month investment was used as the risk-free rate. For each food company the market betas and accounting betas were calculated using two different approaches: the risk measured by variance and downside risk. The calculations begin with market betas and accounting beta for risk measured by variance (Table 1).

The market betas show that AMB is the only company that is more volatile than the market, i.e. its rate of return is more changeable than the market. Eight of the companies are less volatile than the market and five companies behave in a different way to the market. They have negative values of betas coefficient. Looking at accounting Beta the $\beta_i(ROS)$ is extremely high for AST. This means that changes in the sector have a huge influence on the return on sales (ROS) for this company. This can be attributed to two main reasons:

(i) It is one of the biggest companies,
(ii) It reached a high level of ROS in the analysed periods.

Therefore, the ROS for AST has a big impact on the average level of ROS for all the companies in the sector.

It should be noted that for some companies, such as GRL, all versions of betas give a similar value of systematic risk. However there are some companies for which the betas are positive and negative i.e. AMB, IND, MAK, PPS, WLB, WWL. The market rate of return for AMB changes in the same way as the whole market, but the return on sales and the return on assets change in the opposite direction to the sector. Next the correlation between market beta and accounting betas for the mean-variance approach were estimated (Table 2).

Table 1. Food company market betas and accounting beta for risk measured by variance

Food Company	β_i	$\beta_i(ROS)$	$\beta_i(ROA)$	$\beta_i(ROE)$
AMB	1.111	–0.257	–0.020	0.014
AST	0.485	5.083	1.867	2.233
DUD	–0.620	–0.139	–0.376	–0.393
GRL	–0.007	–0.068	–0.061	–0.083
IND	0.305	0.015	–0.012	–0.039
KER	0.436	0.779	1.286	1.216
KSW	–0.123	–0.176	–0.169	–0.234
MAK	0.406	–0.109	–0.086	–0.125
PMP	0.126	0.182	0.254	0.439
PPS	–0.081	–0.316	0.093	0.087
SEK	–0.090	–0.283	–0.212	–0.283
WLB	0.682	–0.023	0.587	3.452
WWL	0.131	–0.023	–0.048	–0.028
ZWC	0.120	0.184	0.268	0.635

Source: Authors' calculation.

Table 2. Correlation between market beta and accounting betas for the mean--variance approach

	β_i	$\beta_i(ROS)$	$\beta_i(ROA)$	$\beta_i(ROE)$
β_i	1.000			
$\beta_i(ROS)$	0.222	1.000		
$\beta_i(ROA)$	0.426	0.847	1.000	
$\beta_i(ROE)$	0.488	0.510	0.743	1.000

Source: Authors' calculation.

In all presented tables, critical value of Pearson coefficient is 0.53 at significance level of 0.05 and 0.46 at significance level of 0.1. There is a positive correlation between market beta and accounting betas. This correlation is moderate for $\beta_i(ROA)$ and $\beta_i(ROE)$, and weak for $\beta_i(ROS)$. The statistical significant correlation arises between $\beta_i(ROE)$ with, $\beta_i(ROA)$ with $\beta_i(ROE)$ and $\beta_i(ROA)$ with $\beta_i(ROS)$.

Then the market betas and accounting betas were calculated using downside risk (Table 3).

Table 3. Market downside betas and downside accounting beta

Food Company	β_i	$\beta_i(ROS)$	$\beta_i(ROA)$	$\beta_i(ROE)$
AMB	0.921	0.342	0.749	0.438
AST	0.565	5.175	2.564	3.008
DUD	0.391	0.594	0.936	0.753
GRL	0.898	0.500	0.818	0.582
IND	0.368	0.614	0.902	0.627
KER	0.578	0.757	1.263	1.075
KSW	0.566	0.249	–0.141	–0.017
MAK	0.520	0.401	0.791	0.614
PMP	1.518	0.954	1.566	1.674
PPS	0.637	0.435	0.977	0.813
SEK	0.864	0.262	0.408	0.222
WLB	1.450	1.797	3.629	8.956
WWL	0.576	–0.612	–1.131	–0.531
ZWC	0.486	0.132	0.198	–3.320

Source: Authors' calculation.

The $\beta_i^{LPM}(ROE)$ for WLB is very high (8.956) which suggests that its return on equity decreases sharply when the food sector experiences difficult trading conditions. The analysis also shows that the systematic downside risk for PMP (1.518) is higher when compared to the variance approach (only 0.126). This company appears less volatile when using market and accounting beta variances individually, and more volatile when using downside risk measures. This means that the market rate of return, as well as accounting profitability, fell faster and deeper when the food sector was weak during the analysed period. It is assumed here that a weak period is when the average profitability ratio for the company is lower than average level in the sector.

The downside betas provide important information to the managers and owners. They inform what could happen to stock prices on capital markets and the accounting profitability when the market weakens.

Looking at downside market betas for all the companies that were analysed, the market rate of return changes in the same direction when the sector is weak (all β_i^{LPM} are positive). However, using the variance approach, the market betas are negative for five companies (compare Table 1). The variance approach and downside approach for each company gives very different information. The correlation matrix is calculated for mean-downside risk approach (Table 4).

Table 4. Correlation between market beta and accounting betas for mean-downside risk approach

	β_i^{LPM}	$\beta_i^{LPM}(ROS)$	$\beta_i^{LPM}(ROA)$	$\beta_i^{LPM}(ROE)$
β_i^{LPM}	1.000			
$\beta_i^{LPM}(ROS)$	0.222	1.000		
$\beta_i^{LPM}(ROA)$	0.426	0.847	1.000	
$\beta_i^{LPM}(ROE)$	0.488	0.510	0.743	1.000

Source: Authors' calculation.

There is a positive correlation between market beta and accounting betas for downside risk. However there is no significant correlation between downside beta for ROS and downside beta, nor is there a correlation between market and accounting betas for variance (compare Table 3 and 4). The statistical significant correlation arises between almost all kinds of downside market and accounting betas. To measure systematic accounting risk the $\beta_i^{LPM}(ROE)$ seems to be the best option as it significantly correlates with downside market beta. Finally, the correlation coefficients between the different kinds of betas for the variance approach and downside risk are calculated (Table 5). There is a positive relationship between betas for variance and for downside risk. However for market betas the correlation is statistically insignificant, but the correlation between accounting betas for ROS is strong

Table 5. Correlation between betas for risk variance approach and downside risk

Variables		Correlation
β_i	β_i^{LPM}	0.315
$\beta_i(ROS)$	$\beta_i^{LPM}(ROS)$	0.921
$\beta_i(ROA)$	$\beta_i^{LPM}(ROA)$	0.579
$\beta_i(ROE)$	$\beta_i^{LPM}(ROE)$	0.783

Source: Authors' calculation.

Conclusions

This paper develops the new concept of downside accounting beta (DAB) as a measure of risk. DAB represents how changes in the profitability of the whole sector affect the profitability of any given company in that sector. Empirical evidence is presented using the data from companies listed in the Polish food sector of the Warsaw Stock Exchange which shows that there are significant similarities between market betas and accounting betas. It also shows that accounting betas using ROA and ROE are positively correlated with market betas and that there is a significant correlation between accounting betas with variance and semi-variance approaches. However market betas and downside market betas have a poor correlation.

The variance approach and downside risk measures can give very different results, which is also the case for both market and accounting beta. When there is a downturn on the capital markets the market portfolio rate of return flows in the opposite direction to a given company. During the period analysed, when the food sector was weak, the accounting betas showed that the average profitability flowed in the opposite direction. It is assumed here that a weak period is when the average profitability ratio for the company is lower than the average level in the sector. The practical implication of this research is that investors, owners and managers can apply DAB using ROA and ROE to calculate the systematic risk of companies not listed on stock markets and consequently to identify the levels of risk associated with companies within the sector.

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